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	Prepared by(s) Paul Dizon	Supersedes LAT-PS-01346-02
	Subsystem/Office Calorimeter Subsystem	
Document Title **CAL Module Vibration Test Procedure**		

Gamma-ray Large Area Space Telescope (GLAST)

Large Area Telescope (LAT)

Calorimeter Module Vibration Test Procedure

DRAFT

DOCUMENT APPROVAL

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CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
01	03 Dec 2002	Initial Release
02	01 Apr 2003	Added Notching Criteria
03	16 April 2003	Added Comments from GLAST Mechanical Team

Table of Contents

List of Figures

List of Tables

1 INTRODUCTION

1.1 PURPOSE

This test procedure contains the requirements and procedures for the structural environment test of the Engineering Model (EM) of the GLAST Calorimeter (CAL) Module. The test results will be presented in a separate test report, GLAST CAL Module EM Vibration Test Report (LAT-RP-01888), upon completion of the test.

1.2 OBJECTIVE

The objective of this test is to qualify the design and workmanship of the GLAST CAL Module EM. This is accomplished by subjecting it to low-level sine sweeps and qualification test levels that exceed the maximum expected launch and ascent dynamic environments. The fundamental frequency of the EM will be verified by subjecting it to low-level sine sweeps. The dynamic environments are simulated by sine vibration, random vibration and sine-burst tests.

1.3 OVERVIEW

Structural environment testing will be done at the Vibration Laboratory of the Naval Research Laboratory, Washington, D.C. It will consist of the standard technique of attaching the test article to either the slip table or vertical head expander and conducting a series of vibration test of various levels and types. Overall responsibility will lie with the test director.

2 APPLICABLE SPECIFICATIONS

Documents required to perform this test will accompany the test article, including the As-Built Configuration List (ABCL) and traveler control sheets. The applicable documents cited in this standard are listed in this section only for reference. The specified technical requirements listed in the body of this document takes precedence over the source document is listed in this section.

2.1 GOVERNMENT SPECIFICATIONS

The following specifications, standards and handbooks form a part of this document to extent specified herein.

Number	Title
GEVS-SE	General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components

2.2 NON-GOVERNMENT SPECIFICATIONS

Number	Title
LAT-SS-00788	LAT Environmental Specification
LAT-SS-01345	CAL Module Verification & Environmental Test Plan
LAT-PS-01370	CAL Module Comprehensive Performance Test Procedure
LAT-PS-01371	CAL Module Limited Performance Test Procedure
LD31572	Vibration Test Report of the GLAST Calorimeter Module, VM2, (16 April 2002, Sopemea-France)
N/A	CAL (Farhad Tahmasebi, 25 Feb 2002)
N/A	Pre-Test Analysis Report for CAL EM3 Module (11 Feb 2003)
N/A	Instrumentation Manuals

2.3 DRAWINGS

Number	Title
GLT-LLR-00-00-B	EM Calorimeter Module, GLAST

2.4 ORDER OF PREFERENCE

In the event of a conflict between this document and the technical guidelines cited in other documents referenced herein, the technical guidelines of this document would take precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3 TEST DECRIPTION

3.1 TEST OBJECTIVE

The objective of this test is to qualify the design and workmanship of the GLAST CAL Module EM by verifying the fundamental frequency and subjecting it to test levels that exceed the maximum expected launch and ascent dynamic environments.

3.2 TEST METHODOLOGY

The structural environmental test is divided into four tests, which are performed on each of the three axes of the EM: the transverse axes (X and Y) and the thrust axis (Z). The four test activities of the structural environmental test are:

- Frequency Survey – to determine the fundamental frequency using a low-level sine sweep.
- Sine Vibration Test – to subject the test article to the low-frequency sine transient and sustained sine environment.
- Random Vibration Test – to subject the test article to the dynamic environment defined by the acceleration spectral density. The test article will also be subjected to low-level random vibration environment to define a pre-test and post-test signature of the test article.
- Sine Burst Test - to subject the test article to a static-equivalent acceleration level

The fundamental frequency of the test article will be verified by means of a frequency survey using a low-level sine sweep. The frequency response function from this survey defines a pre-test low-level signature of the test article. Review of the accelerometer data will determine locations with high response.

Following the frequency survey, a low level random vibration run will define the pre-test signature of the test article prior to subjecting it to the test environments.

The next test in the test flow is the sine vibration test, which is divided into three phases. The first phase is to subject the test article to one-fourth of the full sine vibration test input levels. The second phase is to subject the test article to one-half of the full test input levels and the third phase is to subject it to the full levels. Notching of the vibration levels in the second and third phase will be done, if required.

A low-level random vibration run following the full level sine vibration defines the post-test low-level signature of the test article. Comparison of the frequency response functions before and after the test will determine if there is any structural change to the test article.

Following sine vibration test activities, the test article is subjected to a random vibration test. The random vibration test is also divided into three phases. The first phase is to subject the test article to the –12 dB of the full random vibration level to develop notching criteria. The second phase is to subject the test article to an intermediate random vibration level (–6 dB) and the third phase is to subject it to the full random vibration level. Notching of the vibration levels in the second and third phase will be done, if required.

A low-level random vibration run following the full level random vibration will also define the post-test low-level signature of the test article. Comparison of the frequency response functions before and after the test will determine if there is any structural change to the test article.

Following random vibration test activities, the test article is subjected to a static-equivalent acceleration level by, means of a sine-burst test. A final low-level random vibration run following the sine-burst test defines the post-test low-level signature of the test article. Comparison of the frequency response functions before and after this test will determine if there is any structural change to the test article.

3.3 TEST ARTICLE DESCRIPTION

The test specimen is the EM of the GLAST CAL Tower Module (GLT-LLR-00-A) as documented in the as-built configuration list (ABCL). The Tower Module consists of the CAL Module with the Tracker Electronics Module (TEM) attached to the CAL Module base plate by means of four rigid stand-offs (current LAT design). There are no deviations from the flight configuration with the exception of:

- A Mass Simulator representing the proper mass and centers of gravity of the flight TEM Power Supply (TPS) – SIU electronics boxes is attached to the TEM.
- Electrical Harness from the TPS is removed.

The GLAST CAL Module in flight configuration is shown in Figure 3-1.

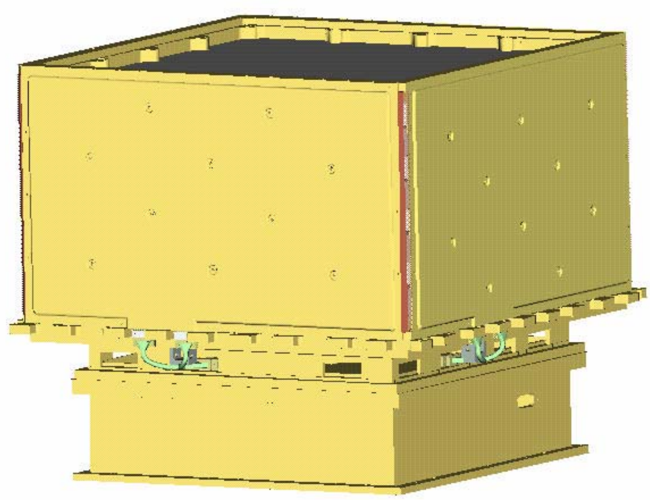


Figure 3-1 – CAL EM in Flight Configuration with TEM/TPS

4 TEST RESPONSIBILITIES

4.1 TEST PERSONNEL

Test personnel are defined below. Responsible points of contact for this test procedure are listed in Table 4-1.

Table 4-1 – Test Personnel

Role	Name	Telephone Number
Project Representative	Eric Grove	202-767-3112
Test Director	Paul Dizon	202-404-7193
Test Conductor, Primary	Bob Haynes	202-767-0705
Test Conductor, Electrical Subsystem	Jim Ampe	202-404-1464
Test Conductor, Science Subsystem	Eric Grove	202-767-3112
Instrumentation/Data Support	Bob Haynes	202-767-0705
Analysis Support	Jim Haughton	202-767-4689
	Chuck Williams	202-767-6696
	Chia Chung Lee	301-902-4215
	Bill Haile	301-902-4261
Quality Assurance Support	Nick Virmani	301-902-4344

4.1.1 Project Representative

The Project Representative represents the GLAST project and will have the responsibility to ensure that no violations of project procedures or CAL handling procedures take place.

4.1.2 Test Director

The Test Director (TD) will have primary responsibility for directing test activities, maintaining the log, documenting the test schedules, coordination of resources, and preparation and close-out of all Discrepancy Reports (DRs) and Non-Conformance Material Reports (NMRs). The TD will also have the primary responsibility for all data collection and evaluation during the test for the final test report. The TD will be responsible for coordinating the inputs from the Test Conductors and Quality Assurance representatives, developing the as-run test file, and for executing the as-run test approval sheet. This includes assuring that all DRs and NMRs have been properly prepared and correctly executed.

4.1.3 Test Conductor

The Test Conductor(s) will be responsible for a specific activity being conducted. The Primary Test Conductor will also be responsible for the entire laboratory, installation and check-out of instrumentation, data acquisition, and data reduction. The other TC(s) will be responsible for executing their specified test procedures. The TC(s) is also responsible for the preparation, operation of test equipment, and the scheduling of daily activities mentioned in the test procedure.

4.1.4 Support Personnel

Support Personnel are responsible for specific activities supporting installation of instrumentation, managing data, and providing real-time data analysis support.

4.2 CONFIGURATION VERIFICATION

Upon completion of the test setup, the Test Director, Test Conductor and Quality Assurance representative must inspect and approve the test configuration and test conditions, prior to the start of the testing and at any key phases of the test.

4.3 TEST DISCREPANCY RESOLUTION

In event of a test discrepancy, which indicates the potential of damage to equipment, a failure of the test article, or a failure of test equipment, testing will be stopped and the condition of the hardware and test setup preserved.
If a test discrepancy occurs, the test will be interrupted and the discrepancy verified. The Test Conductor and Test Director will determine which report (DR or NMR) needs to be prepared and executed. If a discrepancy is verified, a DR will be opened and dispositioned by the Test Director in accordance with LAT-SS-00971, CAL Program Quality Assurance Plan.

In conducting the failure analysis, the Test Director can select and re-run in any sequence, any portion of the full functional test within this procedure. Any test steps, conditions, or procedures that are not a portion of this approved test procedure that needs to be included must first be approved by the TD and QA and a DR generated before they are performed. The results are to be included or referenced in the DR and included in the as-run appendix.

If the discrepancy is dispositioned as a failure of the test article, then a NMR will be opened and dispositioned in accordance with LAT-SS-00971, CAL Program Quality Assurance Plan.

5 GENERAL TEST PROGRAM REQUIREMENTS

5.1 TEST SETUP

5.1.1 Test Location

The structural environmental test will be conducted in the Vibration Test Laboratory of the Payload Check-Out Facility, Building A-59, of the Naval Research Laboratory, Washington, D.C.

5.1.2 Test Article Configuration

The test article will be mounted in the upright position onto a two-piece vibration test fixture. The two-piece test fixture consists of a CAL base plate adapter and the primary fixture, which mounts directly to the slip table of the vibration table. An As-Built Configuration List (ABCL) will be generated for the test article in its test configuration.

5.1.3 Test Equipment

The following test equipment and systems will be used in the execution of this test:

- Test Fixture: GLAST CAL Module
- Test Article Support: CAL Vibration Test Fixture
CAL Hoist Fixture and Accessories
- Accelerometers: Endevco Model TBD Piezoelectric Tri-Axial Accelerometers
- Charge Amplifiers: Endevco Model 2775A Charge Amplifiers
Unholtz Dickie Model D22 Charge Amplifiers
- Vibration Test System: GenRad Model 2550 Vibration Control System
Ling Model 8096B Power Amplifier
Ling Model SSW-1340-230s Switching Unit
- Data Acquisition System: Hewlett Packard VXI Data Analysis System
- CAL Electrical Ground Test Equipment

Any substitution of the designated test equipment will require the approval of the TD and/or the TC, and QA. Such substitutions will be noted as part of the test data and submitted with the test report.

The test fixture, as shown in Figure 5-1, supports the EM in the upright position. Since the EM must be removed from the test fixture each time the assembly is re-oriented for each axis test, the EM is attached to the test fixture via bolt-on interface plates. Because there are 72 fasteners connecting the EM to the interface plates, the bolt-on feature of the plates facilitates the re-orientation process.

The stiffness of this fixture has been tailored to filter the high frequency loads, which could damage the crystals.

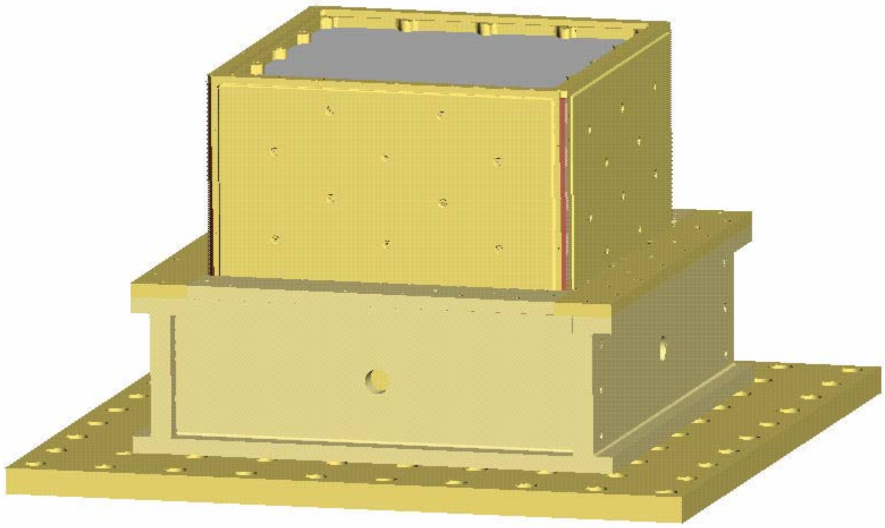


Figure 5-1 – Test Fixture with EM CAL Module

5.1.4 Handling and Control of Equipment

Handling of the EM will be under the direction of the TD and/or TC. The following equipment must be used for the proper and safe handling of the EM:

- Proper EM Grounding Strap for Electrostatic Discharge (ESD) Control
- Grounding Wrist Straps for ESD Control
- Gloves

The EM must be connected to a certified ground strap at all times. All personnel must wear gloves and ground straps when in contact with the EM.

The following equipment must be used for the proper and safe transportation of the EM as well as movement of the EM within the Vibration Facility:

- Shipping Container
- Lift Blocks
- Lift Fixture

The EM is transported to and within the Vibration Facility inside its Shipping Container. The shipping container is wheeled and is also used as a transportation dolly. The EM will be moved and positioned on the shaker table via the facility crane. Interface between the EM and the crane is via the Lift Fixture. Lift Blocks are the attachment points between the Lift Fixture and the EM.

5.2 INSTRUMENTATION AND DATA ACQUISITION

5.2.1 Instrumentation

Eight tri-axial accelerometers will be used to measure the acceleration response of the EM. These accelerometers are attached at points of interest or at points expected to have high acceleration response where notching may be necessary. Furthermore, six tri-axial accelerometers will be attached at each corner of the EM-test fixture interface plane and the vibration table for shaker control.

Table 5-1 lists the accelerometers that are to be used in this series of testing. All accelerometers are to be aligned with the CAL coordinate system shown in Figure 3-1. Accelerometer locations are illustrated in Figure 5-2.

Some of these accelerometer channels will have to be monitored during the random vibration testing of the CAL. The goal is to response limit components with known limitations such that random vibration levels do not exceed component test levels.

Random vibration levels at the base plate interface will be monitored by four tri-axial accelerometers (ID 09 – ID 12) located near four corners of the base plate. Two tri-axial accelerometers will be used for standard control at the shaker table (ID 13 – ID 14).

5.2.2 Calibration

Standard vibration laboratory calibration techniques will be used. Prior to testing, the accelerometers will be calibrated by comparison against a “Standard Accelerometer” traceable to the National Institute of Standards and Technology.

5.2.3 Data Acquisition

All data will be acquired through the VXI Data Acquisition System. The data will be stored on the HP VXI computer in digital format with a sampling rate appropriate for a 2000 Hz minimum bandwidth.

5.2.4 Data Reduction

Time history data will be stored and analyzed on the HP VXI using SDRC/IDEAS test software. Frequency response functions will be generated and stored. All data will be analyzed over the 10 to 2000 Hz frequency range. In addition, response power and force spectral densities and cumulative G_{rms} and Force RMS plots for each channel will be generated to monitor the response levels during testing. Finally, all data plots will contain test description, test date, and name and channel number.

Table 5-1 – Accelerometer Locations

Accelerometer ID	Channel ID	Location	Degree of Freedom
1	01X 01Y 01Z	-X Side Panel – Center	X Y Z
2	02X 02Y 02Z	-X Side Panel – Top	X Y Z
3	03X 03Y 03Z	-Y Side Panel – Center	X Y Z
4	04X 04Y 04Z	-Y Side Panel – Top	X Y Z
5	05X 05Y 05Z	+Z Structure	X Y Z
6	06X 06Y 06Z	+Z Top Frame	X Y Z
7	07X 07Y 07Z	-Z Base Plate – Center	X Y Z
8	08X 08Y 08Z	-Z TEM/PS – Center	X Y Z
9	09X 09Y 09Z	+X,+Y Base Plate	X Y Z
10	10X 10Y 10Z	+X,-Y Base Plate	X Y Z
11	44X 11Y 11Z	-X,+Y Base Plate	X Y Z
12	12X 12Y 12Z	-X,-Y Base Plate	X Y Z
13	13X 13Y 13Z	Vibration Fixture	X Y Z
14	14X 14Y 14Z	Vibration Fixture	X Y Z

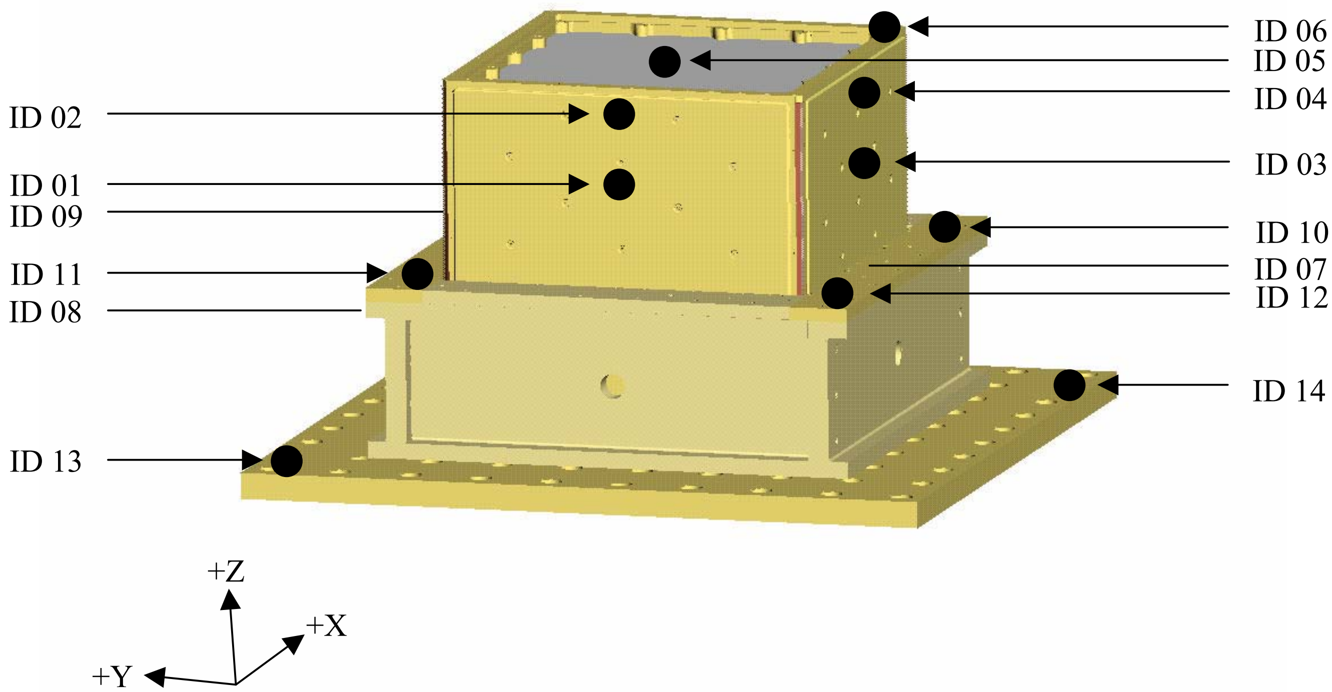


Figure 5-2 – Accelerometer Locations

5.2.5 Test Log

The Test Conductor will maintain a test log of the daily activities during the test. The test log shall contain at a minimum the date and time of each test activity, a brief description of the activity, a description of any deviation from the planned procedure, and any other information known to be significant to the test, such as photographs. Furthermore, the Test Director shall maintain a master copy of the procedure. All deviations from the procedure shall be noted as "red lines" in this master copy.

5.2.6 Test Report

The results of the test will be documented in a separate test report after completion of the testing. The report shall contain all test data, photographs, a complete description of the test and a description of any deviation from this procedure.

6 TEST LEVELS

6.1 LOW-LEVEL SINE SWEEP FOR FREQUENCY SURVEY

Each axis of the CAL EM will be independently subjected to low-level sine-sweep for frequency identification. Table 6-1 contains the low-level sine sweep spectrum to be used. The minimum test duration is 2 minutes, but should be no longer than what is necessary to acquire the low-level data for each accelerometer channel.

Table 6-1 – GLAST CAL Low Level Sine Sweep

	Frequency	Acceleration	Comments
Sweep 1	10 Hz – 1000 Hz	0.25 g	All Sweeps at 2 oct/min

6.2 SINE VIBRATION TEST LEVEL

Each axis of the CAL EM will be independently subjected to the qualification sine vibration test levels shown in Table 6-2. The levels may be notched to limit the CG response of the CAL to the levels outlined in Table 4 of the LAT Environmental Specification. The structure will be subjected to one-fourth and one-half test input levels preceding the full level sine vibration test.

Table 6-2 – GLAST CAL Sine Vibration Qualification Test Levels

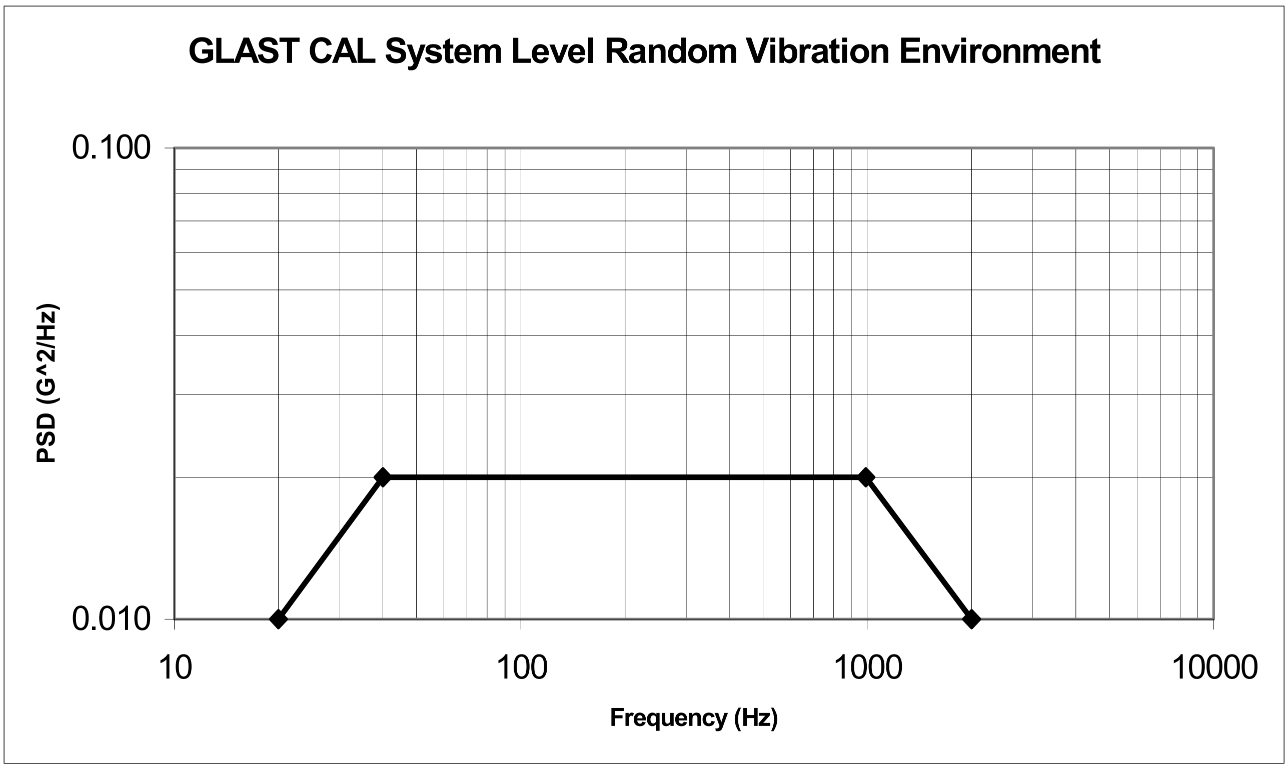
Axis	**Frequency (Hz)** (Hz)	**Qualification Level** (g)	**Sweep Rate** (oct/min)
Lateral (X &Y)	5-15	4.4	4
	15-25	1.9	4
	25-35	1.9	1.5
	35-45	3.8	4
	45-50	4.8	4
Axial (Z)	5-18	2.5	4
	20-25	5.0	4
	25-35	5.0	1.5
	35-40	5.0	4
	42-50	2.5	4

NOTES:
Linear Acceleration Transition from 2.5 g at 18 Hz to 5.0 g at 20 Hz
Linear Acceleration Transition from 5.0 g at 40 Hz to 2.5 g at 42 Hz

6.3 RANDOM VIBRATION TEST LEVEL

Each axis of the CAL EM will be independently subjected to the qualification random vibration environment shown in Figure 6-1. These levels are the same as the GEVS Components Minimum Workmanship values. The spectrum may be tailored to keep primary structural and major component responses below the responses seen during the VM-2 random vibration test. The structure will be subjected to –12 dB and –6 dB random vibration levels preceding the full level random vibration test.

Furthermore, each axis will also be independently subjected to low-level random vibration levels, as shown in Figure 6-2, for system characterization before and after sine vibration, random vibration and sine burst testing.

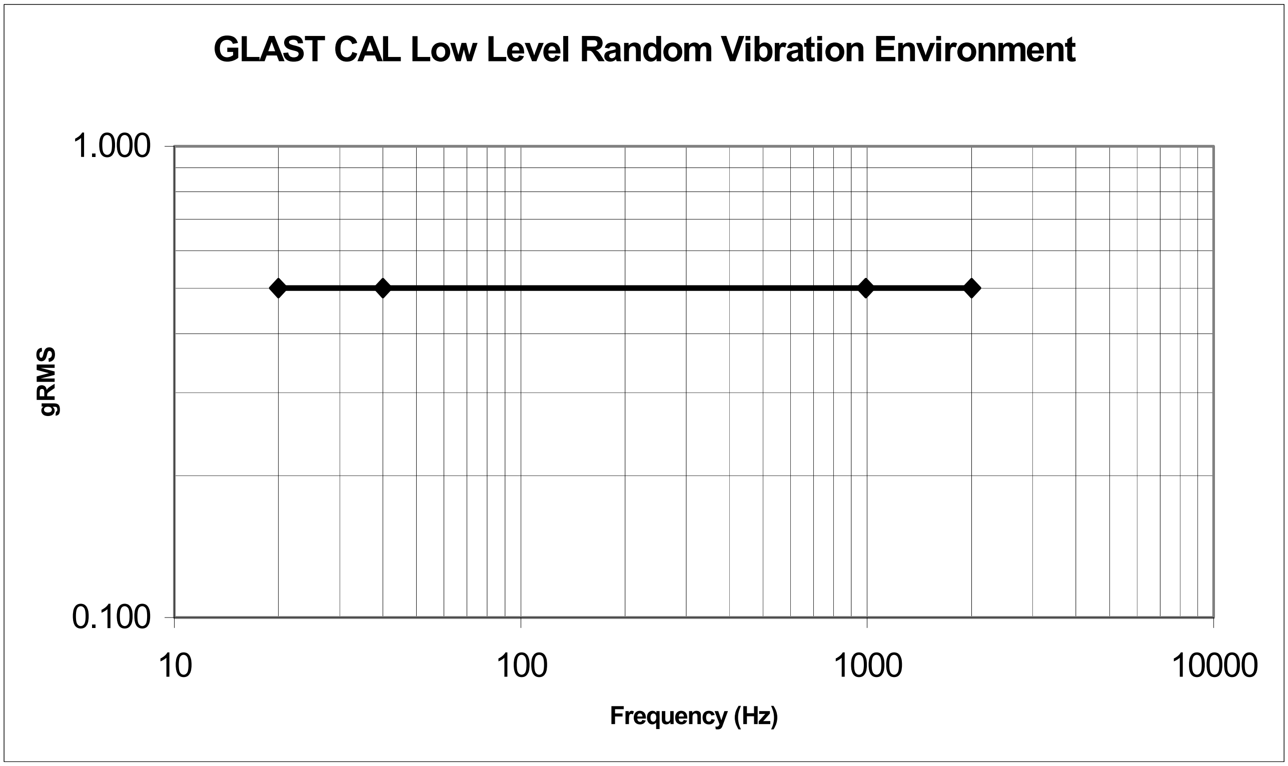


Qualification Levels 5.8 gRMS	
Frequency (Hz)	g^2/Hz
20	0.010
40	0.020
990	0.020
2000	0.010

Test Duration: 2 minutes per axis

Levels Apply to all 3 Axes

Figure 6-1 – GLAST CAL System Level Random Vibration Environment



Qualification Levels	
Frequency (Hz)	gRMS
20	0.500
40	0.500
990	0.500
2000	0.500

Test Duration: 2 minutes per axis

Levels Apply to all 3 Axes

Figure 6-2 – GLAST CAL Low Level Random Vibration Environment

6.4 SINE-BURST TEST LEVEL

Each axis of the CAL EM will be independently subjected to a static-equivalent qualification acceleration level using a sine-burst test level defined in Table 6-3, which is specified in the LAT Environmental Specification. An initial sine-burst at half-level will precede the actual sine-burst test.

Table 6-3 – CAL EM Sine-Burst Test Level

Axis	Frequency	Acceleration	Cycles
X (Transverse)	25 Hz	± 7.5	5
Y (Transverse)	25 Hz	± 7.5	5
Z (Thrust)	25 Hz	± 8.5	5

The input levels shown in Table 6-3 may be modified, based upon review of response data from the sine-burst test at the –6 dB level.

6.5 LIMITING ACCELERATIONS

Pre-test analysis shows that notching is required in all directions around 800 Hz. The notching criteria is:

1) Response at CAL/fixture interface (as measured by the four accelerometers on the test fixture) not to exceed the input specification
2) Responses of CAL not to exceed the following responses measured during verification testing (Figure 6.4-1 through Figure 6.4-5) of the VM2 prototype model. These results are published in the Vibration Test Report of the GLAST Calorimeter Module, VM2, LD31572 (16 April 2002, Sopemea-France).

Notching is expected at the following frequencies under X-Axis and Y-Axis Random Vibration:

- 2-3 dB notch at 160 Hz due to the top section of the –X Side Panel exceeding the defined limits
- 12 dB notch at 820 Hz due to average response at the CAL/fixture interface exceeding the input specification, the center section of the –Y Side Panel exceeding the defined limits, and the lateral mode of the test fixture coupling with the CAL module.

Notching is expected at the following frequencies under Z-Axis Random Vibration:

- 15 dB notch at 740 Hz due to the top section +Z structure and the center section of the –Z base plate exceeding the defined limits, and the vertical mode of the test fixture coupling with the CAL module.
- 10 dB notch at 1050 Hz due to CDEs located within the structure exceeding the defined limits

Automatic notching during random vibration, if desired, may be controlled using response limiting.

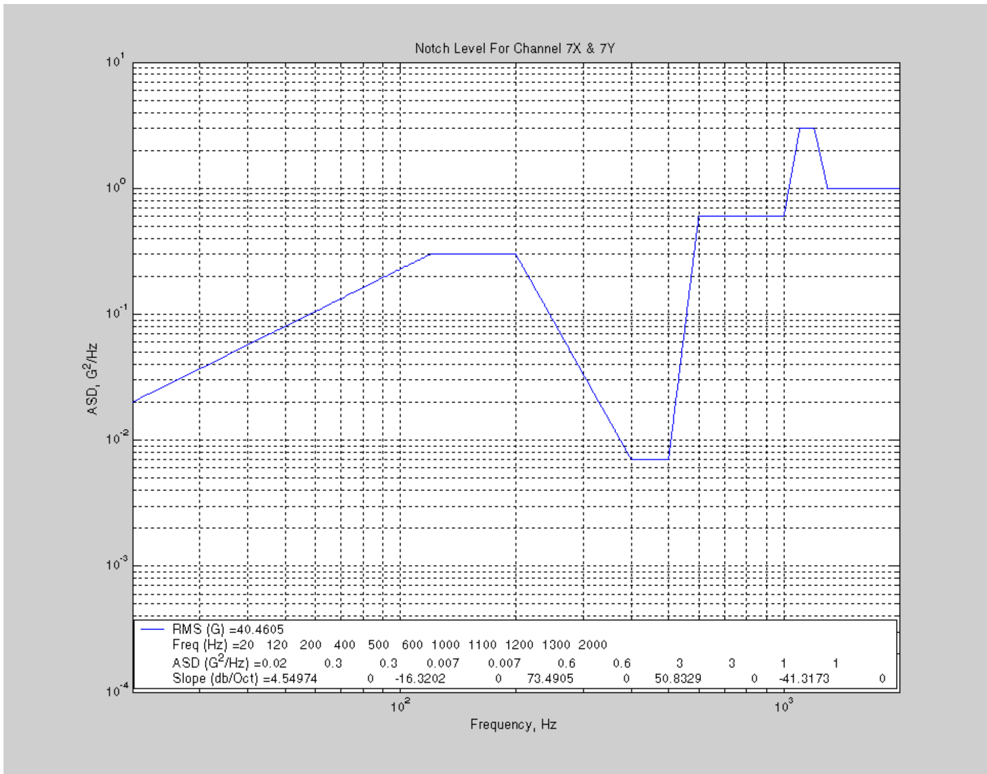


Figure 6.4-1 Notch Level for Channels 01X and 01Y

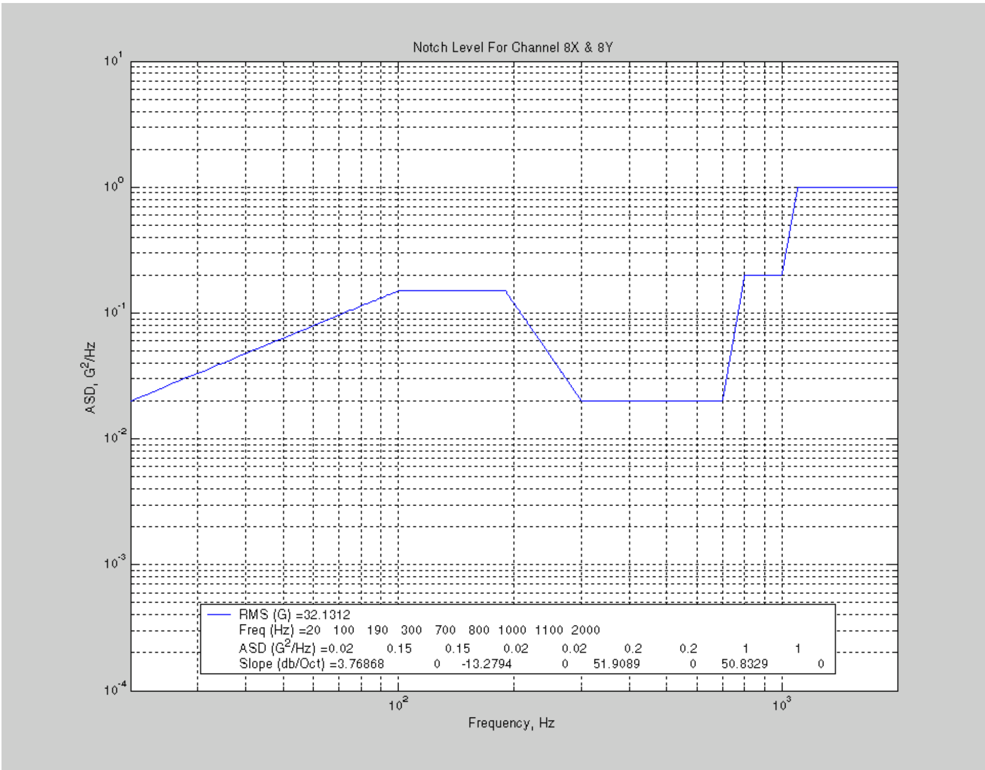


Figure 6.4-2 Notch Level for Channels 02X and 02Y

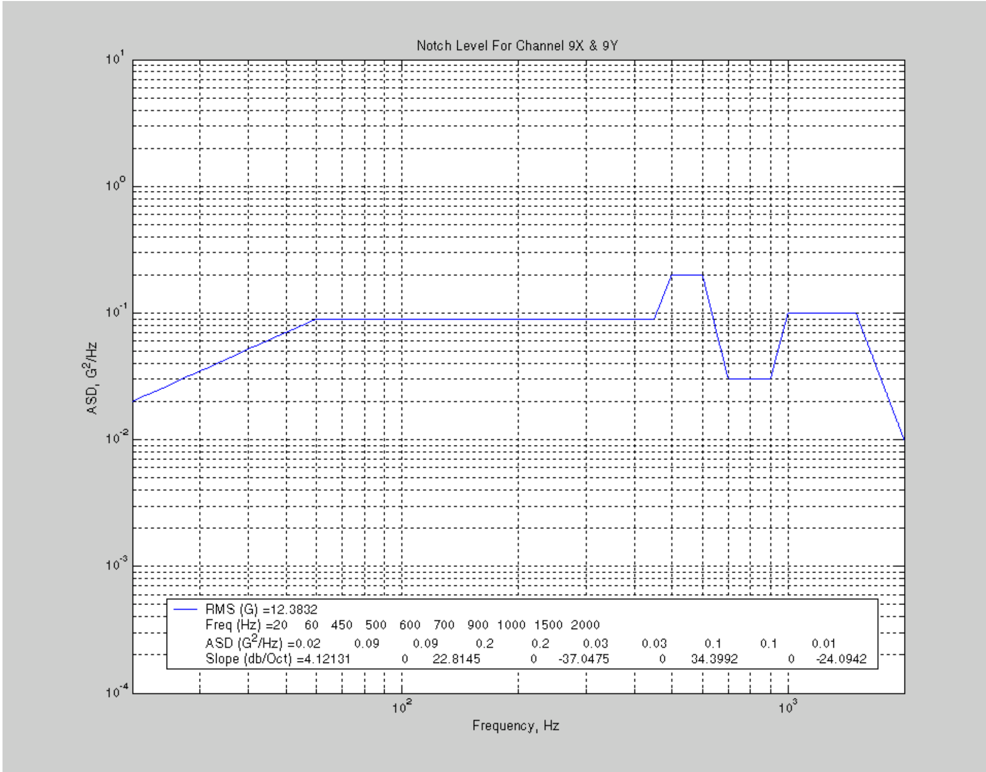


Figure 6.4-3 Notch Level for Channels 03X and 03Y

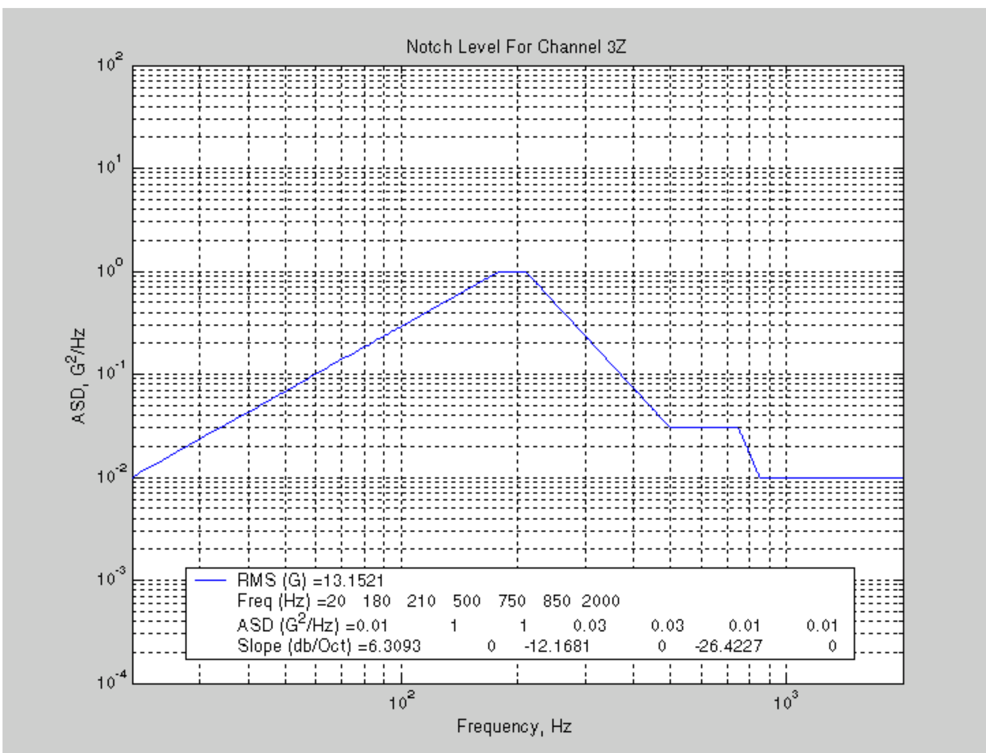


Figure 6.4-4 Notch Level for Channel 05Z

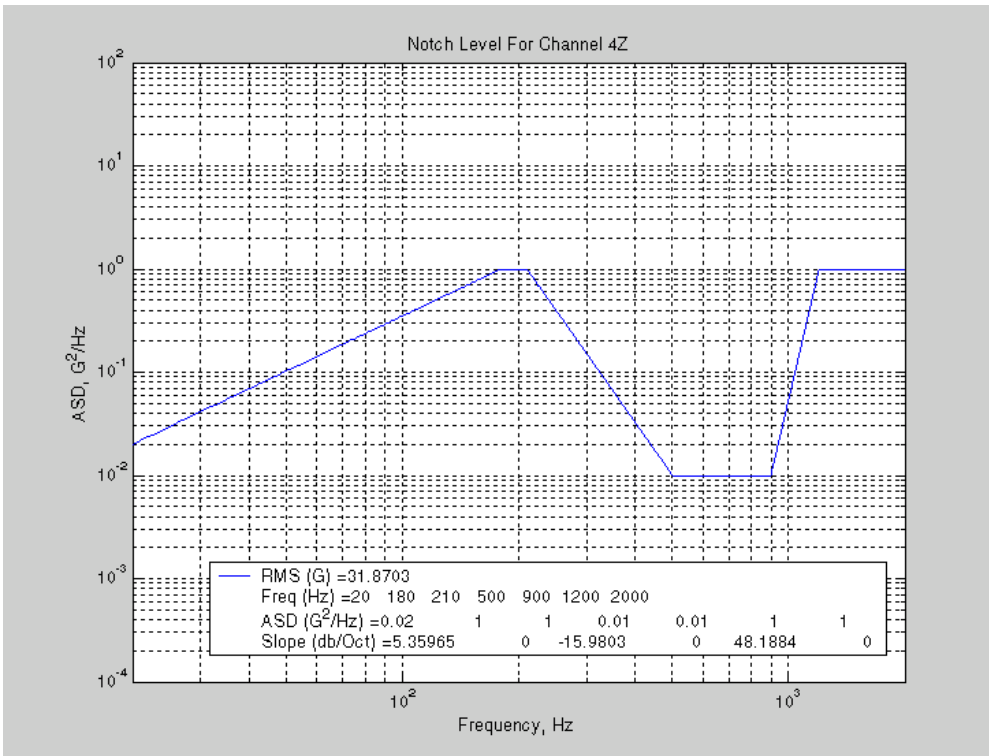


Figure 6.4-5 Notch Level for Channel 07Z

7 TEST PROCEDURE

At the conclusion of the environmental test flow for each axis, two tests are performed to verify that the CAL Module is still functional:

- Electronics Functional Testing occurs at the conclusion of the Post-Test Signature following the Sine-Burst (Final) test event. This functional test is conducted by the Electrical Subsystem Test Conductor in accordance to the test procedure, *CAL Module Limited Performance Test Procedure*, LAT-PS-01371.
- Quick-Look Cosmic Muon test is conducted at the conclusion of the electronics functional test to verify that the Crystal Detector Elements (CDE) of the EM can still collect data. This test is initiated via a script and is conducted by the Science Subsystem Test Conductor.

7.1 Z-AXIS STRUCTURAL ENVIRONMENT TEST FLOW

Run #	Test Description	Frequency (Hz)	Test Level	Duration	Comments
1	Frequency Survey Low-Level Sine-Sweep Signature	Input: 0.25 g 10 Hz -1000 Hz	See Section 6.1	As Required for Data	*Identify modal frequency
2	Low-Level Random Vibration (Pre-Test Signature)	Input: 0.5, gRMS 20 Hz -2000 Hz	See Section 6.3	As Required for Data	Review all accels to determine locations with high response
3	Sine Vibration (1/4 Level)	Input: 5 Hz – 50 Hz	See Section 6.2		Develop Notching Criteria
4	Sine Vibration (1/2 Level)	Input: 5 Hz – 50 Hz	See Section 6.2		Notch if Required
5	Sine Vibration (Full Level)	Input: 5 Hz – 50 Hz	See Section 6.2		Notch if Required, Verify Notching
6	Low-Level Random Vibration (Post-Test Signature)	Input: 0.5, gRMS 20 Hz -2000 Hz	See Section 6.3	As Required for Data	Compare Pre and Post FRFs

Run #	Test Description	Frequency (Hz)	Test Level	Duration	Comments
7	Random Vibration (-12 dB)	Input: 20 Hz –2000 Hz	See Section 6.3	As Required for Data	Develop Notching Criteria
8	Random Vibration (-6 dB)	Input: 20 Hz –2000 Hz	See Section 6.3	As Required for Data	Notch if Required
9	Random Vibration (Full Level)	Input: 20 Hz –2000 Hz	See Section 6.3	2 Minutes (minimum)	Notch if Required, Verify Notching
10	Low-Level Random Vibration (Post-Test Signature)	Input: 0.5, gRMS 20 Hz -2000 Hz	See Section 6.3	As Required for Data	Compare Pre and Post FRFs
11	Sine-Burst (Initial)	Input: $\pm$4.25 gpk, 25 Hz	See Section 6.4	5 Cycles	N/A
12	Sine-Burst (Final)	Input: $\pm$8.5 gpk, 25 Hz	See Section 6.4	5 Cycles	N/A
13	Low-Level Random Vibration (Post-Test Signature)	Input: 0.5, gRMS 20 Hz -2000 Hz	See Section 6.3	As Required for Data	Compare Pre and Post FRFs
14	Functional Testing of Electronics	N/A	N/A	N/A	N/A
15	Cosmic Muon Quick-Look Test	N/A	N/A	N/A	N/A
16	Frequency Survey Low-Level Sine-Sweep Signature	Input: 0.25 g 10 Hz -1000 Hz	See Section 6.1	As Required for Data	*Verify modal frequency

* Maximum allowable frequency shift between the pre- and post-test measurement of the fundamental frequency must be within 5%.

7.2 X-AXIS STRUCTURAL ENVIRONMENT TEST FLOW

Run #	Test Description	Frequency (Hz)	Test Level	Duration	Comments
1	Frequency Survey Low-Level Sine-Sweep Signature	Input: 0.25 g 10-1000 Hz	See Section 6.1	As Required for Data	*Identify modal frequency
2	Low-Level Random Vibration (Pre-Test Signature)	Input: 0.5, gRMS 20 Hz -2000 Hz	See Section 6.3	As Required for Data	Review all accels to determine locations with high response
3	Sine Vibration (1/4 Level)	Input: 5 Hz – 50 Hz	See Section 6.2		Develop Notching Criteria
4	Sine Vibration (1/2 Level)	Input: 5 Hz – 50 Hz	See Section 6.2		Notch if Required
5	Sine Vibration (Full Level)	Input: 5 Hz – 50 Hz	See Section 6.2		Notch if Required, Verify Notching
6	Low-Level Random Vibration (Post-Test Signature)	Input: 0.5, gRMS 20 Hz-2000 Hz	See Section 6.3	As Required for Data	Compare Pre and Post FRFs
7	Random Vibration (-12 dB)	Input: 20 Hz –2000 Hz	See Section 6.3	As Required for Data	Develop Notching Criteria
8	Random Vibration (-6 dB)	Input: 20 Hz –2000 Hz	See Section 6.3	As Required for Data	Notch if Required
9	Random Vibration (Full Level)	Input: 20 Hz –2000 Hz	See Section 6.3	2 Minutes (minimum)	Notch if Required, Verify Notching

Run #	Test Description	Frequency (Hz)	Test Level	Duration	Comments
10	Low-Level Random Vibration (Post-Test Signature)	Input: 0.5, gRMS 20 Hz -2000 Hz	See Section 6.3	As Required for Data	Compare Pre and Post FRFs
11	Sine-Burst (Initial)	Input: ±3.75 gpk, 25 Hz	See Section 6.4	5 Cycles	N/A
12	Sine-Burst (Final)	Input: ±7.5 gpk, 25 Hz	See Section 6.4	5 Cycles	N/A
13	Low-Level Random Vibration (Post-Test Signature)	Input: 0.5, gRMS 20 Hz -2000 Hz	See Section 6.3	As Required for Data	Compare Pre and Post FRFs
14	Functional Testing of Electronics	N/A	N/A	N/A	N/A
15	Cosmic Muon Quick-Look Test	N/A	N/A	N/A	N/A
16	Frequency Survey Low-Level Sine-Sweep Signature	Input: 0.25 g 10 Hz -1000 Hz	See Section 6.1	As Required for Data	*Verify modal frequency

* Maximum allowable frequency shift between the pre- and post-test measurement of the fundamental frequency must be within 5%.

7.3 Y-AXIS STRUCTURAL ENVIRONMENT TEST FLOW

Run #	Test Description	Frequency (Hz)	Test Level	Duration	Comments
1	Frequency Survey Low-Level Sine-Sweep Signature	Input: 0.25 g 10-1000 Hz	See Section 6.1	As Required for Data	*Identify modal frequency
2	Low-Level Random Vibration (Pre-Test Signature)	Input: 0.5, gRMS 20 Hz -2000 Hz	See Section 6.3	As Required for Data	Review all accels to determine locations with high response
3	Sine Vibration (1/4 Level)	Input: 5 Hz – 50 Hz	See Section 6.2		Develop Notching Criteria
4	Sine Vibration (1/2 Level)	Input: 5 Hz – 50 Hz	See Section 6.2		Notch if Required
5	Sine Vibration (Full Level)	Input: 5 Hz – 50 Hz	See Section 6.2		Notch if Required, Verify Notching
6	Low-Level Random Vibration (Post-Test Signature)	Input: 0.5, gRMS 20 Hz -2000 Hz	See Section 6.3	As Required for Data	Compare Pre and Post FRFs
7	Random Vibration (-12 dB)	Input: 20 Hz –2000 Hz	See Section 6.3	As Required for Data	Develop Notching Criteria
8	Random Vibration (-6 dB)	Input: 20 Hz –2000 Hz	See Section 6.3	As Required for Data	Notch if Required
9	Random Vibration (Full Level)	Input: 20 Hz –2000 Hz	See Section 6.3	2 Minutes (minimum)	Notch if Required, Verify Notching

Run #	Test Description	Frequency (Hz)	Test Level	Duration	Comments
10	Low-Level Random Vibration (Post-Test Signature)	Input: 0.5, gRMS 20 Hz -2000 Hz	See Section 6.3	As Required for Data	Compare Pre and Post FRFs
11	Sine-Burst (Initial)	Input: ±3.75 gpk, 25 Hz	See Section 6.4	5 Cycles	N/A
12	Sine-Burst (Final)	Input: ±7.5 gpk, 25 Hz	See Section 6.4	5 Cycles	N/A
13	Low-Level Random Vibration (Post-Test Signature)	Input: 0.5, gRMS 20 Hz -2000 Hz	See Section 6.3	As Required for Data	Compare Pre and Post FRFs
14	Functional Testing of Electronics	N/A	N/A	N/A	N/A
15	Cosmic Muon Quick-Look Test	N/A	N/A	N/A	N/A
16	Frequency Survey Low-Level Sine-Sweep Signature	Input: 0.25 g 10 Hz -1000 Hz	See Section 6.1	As Required for Data	*Verify modal frequency

* Maximum allowable frequency shift between the pre- and post-test measurement of the fundamental frequency must be within 5%.

7.4 POST-STRUCTURE ENVIRONMENT FUNCTIONAL TESTING

At the conclusion of the environmental test flow for all axes, the CAL Module is removed from the test fixture and transported to the electronics test laboratory for comprehensive functional testing.

7.4.1 Comprehensive Functional Testing of AFEE and TEM Electronics

Following structural environmental testing, a comprehensive functional test of the AFEE and TEM electronics is performed. This test is performed in accordance to the test procedure, *CAL Module Comprehensive Performance Test Procedure*, LAT-PS-01370.

7.4.2 Comprehensive Cosmic Muon Test

Once the functionality of the AFEE and TEM has been verified, a comprehensive test of the CDE is performed to verify that the CDEs are able to collect cosmic muon data.

8 PASS/FAIL CRITERIA

The GLAST CAL Module will have passed this series of testing if the following criteria are met:

- The qualification test levels are applied in accordance with this procedure.
- No detrimental damage is incurred by the GLAST CAL Module.
  - Pre and Post FRFs indicate no significant changes in dynamic response (less than 5% frequency shift).
  - Visual inspections show no physical damage.
- Acquisition of data is recorded and suitable for correlation with the FEA models.
- Successful functional testing of the AFEE and TEM electronics following each random vibration and sine-burst test.
- Successful cosmic muon tests
  - Quick-look cosmic muon test following the structural environmental test flow for each axis
  - Complete Cosmic Muon Test at the end of the structural environmental test flow.